VARIATION IN ORTHOPEDIC SURGEONS' PERCEPTIONS OF THE INDICATIONS FOR AND OUTCOMES OF KNEE REPLACEMENT

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Abstract • Résumé

Objective: To determine the agreement among orthopedic surgeons' indications for knee replacement, their perceptions of the usefulness of various treatments for osteoarthritis of the knee and their expected outcomes of knee replacement, and to determine the relation between these opinions and the number of knee replacement procedures performed by individual surgeons.

Design: Survey.

Setting: Ontario.

Participants: All 392 orthopedic surgeons in the province. Of the 325 practising traceable surgeons 234 (72.0%) responded.

Outcome measures: Indications for knee replacement, perceived usefulness of treatments for osteoarthritis, perceived outcomes of knee replacement and number of knee replacement procedures performed by individual surgeons.

Results: The respondents disagreed on how 20 of 34 patient characteristics affected their decision to perform knee replacement surgery. They also disagreed on the usefulness of seven of eight treatments for arthritis of the knee. The respondents demonstrated variation in their expected outcomes of knee replacement. The surgeons who performed more procedures judged, on average, the outcomes to be better and to have fewer complications than the surgeons who performed fewer procedures.

Conclusions: Orthopedic surgeons demonstrated disagreement about some of the indications for knee replacement, the usefulness of treatments for arthritis of the knee and the perceived outcomes of knee replacement. The areas of greatest disagreement should be the focus of future research and the development of practice guidelines.

Objectif : Déterminer dans quelle mesure il y a, entre les chirurgiens orthopédistes, entente sur les indications relatives à l'arthroplastie du genou, ce qu'ils pensent de l'utilité des divers traitements de l'arthrose du genou, les résultats qu'ils attendent de l'arthroplastie du genou, et le lien entre ces opinions et le nombre d'arthroplasties du genou pratiquées par chaque chirurgien.

Conception : Sondage.

Contexte : Ontario.

Participants : Les 392 chirurgiens orthopédistes de la province. Parmi les 325 chirurgiens praticiens qu'on a pu rejoindre, 234 (72,0 %) ont répondu.

Mesures de résultats : Indications relatives à l'arthroplastie du genou, utilité perçue des traitements de l'arthrose, résultats perçus de l'arthroplastie du genou et nombre d'arthroplasties du genou pratiquées par chaque chirurgien.

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Résultats : Les répondants n'étaient pas d'accord sur la façon dont 20 des 34 caractéristiques des patients ont affecté leur décision de pratiquer une arthroplastie du genou. Ils ne s'entendaient pas non plus sur l'utilité de sept des huit traitements de l'arthrite du genou. Les résultats attendus de l'arthroplastie varient selon les répondants. Les chirurgiens qui ont pratiqué le plus d'arthroplasties ont jugé en moyenne que les résultats étaient meilleurs et que les complications étaient moins nombreuses que les chirurgiens qui en ont effectué moins.

Conclusions : Les chirurgiens orthopédistes ne s'entendent pas sur certaines des indications relatives à l'arthroplastie du genou, sur l'utilité des traitements de l'arthrite du genou et sur les résultats perçus des arthroplasties du genou. Les points sur lesquels les divergences de vues sont les plus marquées devraient faire l'objet d'autres recherches et il faudrait établir des guides de pratique à cet égard.

The rates of many medical and surgical procedures have been shown to vary according to geographic location, a phenomenon called area variation.[1,2] Area variation in the rates of knee replacement, a common surgical procedure, has been demonstrated in Canada[3] and the United States.[4,5] Knee replacement effectively relieves pain and functional disability for patients with moderate to severe arthritis of the knee.[6] Most patients have continued relief of pain 10 years after the procedure, without the need for subsequent operation or revision of the knee replacement.[6,7] Approximately 4500 knee replacement procedures are performed annually in Ontario,[3] and 120 000 are performed annually in the United States, with a total cost of $25 000 to $30 000 (US) per procedure in the United States (comparable Canadian figures are not available).[6]

Area variation in the rates of knee replacement may occur for many reasons, including differences in disease prevalence or severity, differences in patients' and surgeons' expectations and preferences for treatment, and restricted access to surgeons or the procedure. Geographic variation in the rates not accounted for by disease prevalence or severity may be partially explained by underuse of the procedure in some areas, overuse in other areas or a combination of the two.[8] This suggests that some decisions made by physicians are variable and may be arbitrary; "the very disturbing implication is that this arbitrariness represents, for at least some patients, suboptimal or even harmful care."[9] Studies have suggested that up to 30% of some surgical procedures, such as carotid endarterectomy, are being inappropriately performed.[10] Thus, provided the rates have been adequately adjusted for prevalence and severity of disease, and patient preferences for treatment have been considered, geographic variation should be minimized. Reduction in geographic variation has been one of the main factors stimulating the "outcomes" movement. Because knee replacement is an expensive procedure, reduction in geographic variation may also reduce health care expenditures.

Many aspects of the care of patients receiving knee replacement surgery remain uncertain. The literature is controversial and contradictory with regard to the effect of many patient factors, such as type of arthritis, weight and age, on the outcome of surgery.[7,11–13] Controversy also exists concerning the usefulness of certain perioperative treatments, such as continuous passive motion.[6] Finally, the reported success rates and revision rates of knee replacement vary widely.[14]

Surgeons' opinions about the usefulness of knee replacement may affect the decision to perform the procedure for an individual patient. Furthermore, surgeons' opinions and advice may affect patients' decisions when, or if, to proceed with surgery. The purpose of this study was to determine the extent of agreement among practising surgeons on the indications for knee replacement; the perceived usefulness of various treatments for moderate to severe osteoarthritis; and surgeons' perceptions about the usefulness and outcomes of knee replacement, and how these perceptions differ according to the number of procedures performed.

Methods

We surveyed all 392 orthopedic surgeons in Ontario. We obtained their names and addresses from the Ontario Orthopaedic Association or the Physician/Practitioner/Group Demographic file of the Ontario Ministry of Health (if surgeons had submitted a claim for a total knee replacement procedure during the fiscal years 1984 to 1990). Surgeons were excluded from the survey if they were not in active practice or did not reside in the province. The surgeons were surveyed in four separate mailings between March and June 1992.

The questionnaire used in this study was based on a shorter questionnaire previously used in a survey of orthopedic surgeons in the United States.[15] Three separate pilot studies had been conducted to ensure that the questionnaire was clear and comprehensible.[15] First, the questionnaire was mailed to a random sample of 50 orthopedic surgeons. After revisions, the questionnaire was mailed to a second random sample of 50 orthopedic surgeons. Finally, the questionnaire was administered to a group of orthopedic house staff, and the responses were reviewed to ensure comprehensibility.

Our questionnaire sought the following information:

demographic information (age, sex, year of graduation, number of patients with arthritis of the knee treated in the previous year, university or community practice, and solo or group practice), whether the surgeon had treated or referred for treatment patients with severe arthritis of the knee in the previous year, and opinions on the usefulness of treatments for patients with arthritis of the knee, the indications for knee replacement, the usefulness of anticoagulant therapy and continuous passive motion after knee replacement, and patients' outcomes after knee replacement. The analysis was restricted to surgeons who treated patients with arthritis of the knee. The study was approved by the Ethics Review Committee of the University of Toronto. All information about participating surgeons was strictly confidential. A copy of the questionnaire is available from the authors on request.

The surgeons were asked the usefulness of the following treatments for patients with arthritis of the knee: therapy with nonsteroidal anti-inflammatory drugs, analgesic therapy, physiotherapy, arthroscopy, synovectomy, osteotomy, hemiarthroplasty and total knee replacement. In the analysis we included the responses of all of the surgeons because even surgeons who do not perform knee replacements need to be cognizant of the indications for and outcomes of the procedure, since they often refer patients to other surgeons for knee replacement.

Three different approaches were used to determine opinions about indications for knee replacement. First, the surgeons were requested to indicate whether each of 34 patient characteristics made them more likely to perform knee replacement, did not affect their decision or made them less likely to perform knee replacement. The 34 characteristics were identical to those in a previous survey[15] and were derived from a literature review used for a meta-analysis evaluating the outcomes of knee replacement.[14] The 34 characteristics were reviewed by the Ontario and US orthopedic advisory boards (with representatives from the Ontario Orthopaedic Association and the American Academy of Orthopedic Surgery) to the Patient Outcome Research Team, University of Indiana, Indianapolis. The advisory boards reached informal consensus that these were the most relevant factors affecting orthopedic surgeons' decisions to perform knee replacement. Second, the surgeons were presented with detailed written descriptions of three typical hypothetical patients with osteoarthritis describing their signs, symptoms, physical examination and radiologic findings, and previous nonoperative treatments[16] (Appendix 1). The surgeons were asked the likelihood of their using each of the following treatments for the three patients: nonoperative medical management, arthroscopy, osteotomy, unicompartmental knee replacement and tricompartmental knee replacement. Third, the surgeons were asked to describe their typical patient receiving knee replacement surgery using three modified questions from the Hospital for Special Surgery Knee Rating[17] and the 1989 Knee Society Evaluation score[18] describing pain, difficulty walking and difficulty going up and down stairs.

Finally, the surgeons were asked to estimate the proportions of patients with various outcomes, both positive and negative, of primary knee replacement, including relief of pain, improved ability to walk, complication rates and revision rates. For this final analysis the surgeons were classified into four groups: those who did not treat patients with arthritis of the knee, those who treated patients with arthritis of the knee but did not perform knee replacement surgery during the fiscal years 1984 to 1990, those with a low volume of knee replacement procedures (less than or equal to the median number per year) and those with a high volume of procedures (more than the median number per year). The Ontario Health Insurance Plan physician claims database was used to determine the total number of knee replacement procedures performed from 1984 to 1990 by all 392 surgeons. The mean number of procedures performed per year was 4500.

For statistical analysis we used the rank-sum test, Kendall's tau and the Kruskal–Wallis test for nonparametric comparisons. The χ^2 statistic or Fisher's exact test was used to contrast proportions. All tests were two-tailed, with a significance level of 0.05.

We wanted to determine whether the surgeons' demographic and practice characteristics affected their responses to how the 34 patient factors influenced their decision to perform knee replacement surgery and their perceptions of the outcomes of the procedure. However, evaluating the effect of surgeon characteristics on the response to each individual item would have required many statistical tests and would probably have led to statistical significance by chance. Instead, we evaluated whether the surgeons' characteristics were related to their responses to the two groups of questions as a whole (how the 34 patient factors affected their decision to perform knee replacement and the expected outcomes of the procedure). We called this analysis *"variation from the norm"*: the sum of the absolute values of the difference between each surgeon's response to the individual items and the median response. The sums for the two groups of questions were divided by the number of items the surgeon answered in the two groups of questions. Finally, we compared the surgeons' demographic and practice characteristics using two multiple linear regression models, the dependent variable being the variation from the norm for the summed responses to the two groups of questions.

Results

Of the 392 physicians surveyed 67 were excluded for the following reasons: 17 were retired, 11 were not currently practising, 6 were not orthopedic surgeons, 5 were dead, and 28 were untraceable. Of the remaining 325 questionnaires 234 were returned, for a response rate of 72.0%. Of the 234 respondents 205 (87.6%) indicated that they had treated patients with severe osteoarthritis of the knee in the previous year, and 190 (81.2%) had performed knee replacement surgery during the fiscal years 1984 to 1990. A few significant differences were noted between the respondents and the nonrespondents: the latter were slightly older, were less likely to have graduated in Canada and had performed fewer knee replacement procedures during the study period (Table 1). Age, sex, site of practice, year of graduation, university versus community practice, solo versus group practice and number of years since completion of training were not related to the variation from the norm for either indications for knee replacement or expected outcomes ($p \geq 0.05$).

The surgeons' perceptions of the usefulness of the treatments available for patients with moderate to severe osteoarthritis of the knee are shown in Table 2. The respondents agreed about the usefulness of total knee replacement, with 90.7% judging it very or extremely useful. Synovectomy appeared to play a limited role in treatment, with 66.3% of the respondents indicating it to be not at all useful. For the remainder of the medical treatments, however, the perceived usefulness was more variable. For example, 13.7% of the respondents considered physiotherapy to be not at all useful, whereas 8.8% indicated that it was very or extremely useful.

Table 3 shows how the 34 patient characteristics affected the respondents' decision to perform knee replacement. Clinical agreement was considered to exist if 90% or more of the respondents answered in a similar way. Because the threshold of 90% is somewhat arbitrary, Table 3 provides the proportions of respondents to permit evaluation of agreement with alternative thresholds. Patients' sex and race had no effect on the decision to perform knee replacement. Patient characteristics that made the respondents less likely to perform the procedure included local active skin infection, major psychiatric disorder, alcohol or drug abuse, and high physical demands at work. Pain unresponsive to drug therapy made the respondents more likely to perform knee replacement. For the remaining patient characteristics there was clinical disagreement as to how they affect the decision to perform knee replacement.

The surgeons with a high volume of knee replacement procedures were more likely than those with a low volume of procedures to perform knee replacement in patients who were under 55 years of age ($r_s = 0.2$, $p = 0.005$), were obese ($r_s = 0.2$, $p = 0.001$), could not walk more than one block without pain ($r_s = 0.16$, $p = 0.02$), had pain at night ($r_s = 0.14$, $p = 0.05$), had pain unresponsive to drug therapy ($r_s = 0.14$, $p = 0.04$) or had had septic knee arthritis more than 1 year earlier ($r_s = 0.21$,

Table 1: Demographic and practice characteristics of Ontario orthopedic surgeons who responded to the survey and those who did not respond

Characteristic	Respondents (n = 234)	Nonrespondents (n = 91)	*p* value
Male, %	96	99	0.2
Mean yr of licensing	1973	1966	0.0001
Mean yr of graduation	1970	1965	0.0001
Mean yr of birth	1945	1939	0.0001
Urban practice, %	82	86	0.5
Graduated in Canada v. other country, %	79	68	0.04
Graduated in Ontario v. other province, %	62	64	0.8
No. of knee replacement procedures per yr from 1984 to 1990, %			
0	19	33	
1–20	27	23	
21–50	24	23	
> 50	31	20	
Mean no. of knee replacement procedures per yr from 1984 to 1990	59	34	0.01

$p = 0.003$). Surgeons with a high volume of procedures were also less likely to perform knee replacement in patients who were employed ($r_s = -0.2$, $p = 0.004$). The rest of the patient characteristics were not related to the number of procedures performed.

The 205 surgeons who treated patients with arthritis of the knee disagreed on the management of the three hypothetical patients (Table 4). For the first patient (a 55-year-old businessman with a varus knee and moderate medial compartmental osteoarthritis) nonoperative treatment would be used rarely or never by 24.4% of the respondents and often or always by 18.5%. A total of 61.5% of the respondents felt that unicompartmental knee replacement was never or rarely indicated in such a patient, but 10.7% would often or always perform this procedure. For the second patient (a 70-year-old woman with a varus knee and severe tricompartmental osteoarthritis) nonoperative management would be used often or always by 15.6% of the respondents and never or rarely by 42.0%. The corresponding figures for arthroscopic débridement were 8.3% and 62.4%. Tricompartmental knee replacement appeared to be the preferred treatment for such a patient, with 78.5% of the respondents indicating that they would perform it often or always. For the third patient (a 65-year-old retired man with a varus knee and moderate tricompartmental osteoarthritis) considerable variation in the responses was noted for nonoperative treatment, with 17.6% of the respondents indicating that they would use it never or rarely and 38.0%, often or always. The corresponding values for tricompartmental knee replacement were 37.1% and 23.4%.

For the first hypothetical patient the surgeons with a high volume of knee replacement procedures were more likely than those with a low volume of procedures to recommend tricompartmental knee surgery ($r_s = 0.14$, $p = 0.05$). For the second patient the surgeons with a high volume of procedures were less likely than the low-volume group to recommend nonoperative treatment ($r_s = -0.22$, $p = 0.004$) and arthroscopic débridement ($r_s = -0.23$, $p = 0.001$) and were more likely to recommend knee replacement ($r_s = 0.14$, $p = 0.04$). For the third patient the surgeons with a high volume of procedures were more likely to recommend osteotomy than were the surgeons with a low volume of procedures ($r_s = 0.2$, $p = 0.01$).

The respondents indicated that before receiving knee replacement their patients had significant pain and functional disability. A total of 97% of their patients were graded as having moderate or severe pain, 95% were able to walk only five blocks or less, and 99% either required assistance or were unable to climb up or down stairs.

A total of 10% of the respondents judged perioperative anticoagulant therapy to be somewhat or not at all effective in reducing the likelihood of pulmonary embolism, whereas 20% felt that it was extremely effective. Similar variability was found for continuous passive motion, with 13% of the respondents indicating that it was not at all useful and 22% indicating that it was very or extremely useful.

The expected outcomes of knee replacement are shown in Table 5. Compared with the low-volume group, the surgeons with a high volume of knee replacement procedures estimated that a higher proportion of patients would have reduction in pain ($r_s = 0.28$, $p = 0.001$), improvement in walking ability ($r_s = 0.22$, $p = 0.002$) and improved quality of life ($r_s = 0.22$, $p = 0.01$),

Table 2: Surgeons' perceptions of the usefulness of treatments for patients with moderate to severe osteoarthritis of the knee

Treatment	Usefulness; no. (and %) of respondents*			
	Not at all useful	Somewhat or reasonably useful	Very or extremely useful	No answer
Medical therapy with nonsteroidal anti-inflammatory drugs	2 (1.0)	157 (76.6)	46 (22.4)	0
Analgesic therapy alone	33 (16.1)	161 (78.5)	11 (5.4)	0
Physiotherapy	28 (13.7)	158 (77.1)	18 (8.8)	1 (0.5)
Arthroscopy	8 (3.9)	147 (71.7)	49 (23.9)	1 (0.5)
Synovectomy	136 (66.3)	61 (29.8)	4 (2.0)	4 (2.0)
Osteotomy	12 (5.8)	106 (51.7)	80 (39.0)	7 (3.4)
Hemiarthroplasty	33 (16.1)	101 (49.3)	60 (29.3)	11 (5.4)
Total knee replacement	3 (1.5)	14 (6.8)	186 (90.7)	2 (1.0)

*The responses of the 205 surgeons who treated patients with osteoarthritis of the knee were included.

with lower rates of deep infection ($r_s = -0.24$, $p = 0.004$) and lower revision rates at 1, 5 and 10 years ($r_s = 0.22$ to 0.3, $p < 0.002$). Overall, the median proportion of patients expected to need revision within 10 years after knee replacement surgery was 10% to 20% but ranged from 1% to 95%.

Discussion

The respondents in our study disagreed about many of the indications for knee replacement, the treatment options for patients with osteoarthritis and the perceived outcomes of knee replacement. These opinions were not consistently affected by any of the surgeons' demographic or practice characteristics studied except for the number of procedures performed: surgeons who performed more procedures indicated the outcomes to be better and the complications fewer than surgeons who performed fewer procedures. A US study in which a shorter questionnaire was used also showed disagreement among surgeons on how patient factors affected their decision to perform knee replacement and the perceived outcomes of the procedure.[15]

Disagreement among surgeons about the indications for knee replacement provides one explanation for geographic variation in the rates of the procedure. Our respondents disagreed on how patient characteristics would affect their decision to perform knee replacement for over half of the 34 factors examined. Neither the age of the surgeon nor the year of graduation was associated with a treatment choice. Thus, more recently trained surgeons did not appear to demonstrate greater consensus on the indications for and outcomes of knee replacement. When advising individual patients on the advis-

Table 3: Effect of patient characteristics on surgeons' decision to perform knee replacement

Patient characteristic	Effect; no. (and %) of respondents*			
	Less likely to perform knee replacement	No effect	More likely to perform knee replacement	No response
Clinical agreement†				
Less likely to perform knee replacement				
Local active skin infection	183 (99.4)	1 (0.5)	0	6
Major psychiatric disorder	177 (96.2)	7 (3.8)	0	6
Alcohol or drug abuse	172 (94.0)	11 (6.0)	0	7
High physical demands at work	173 (94.0)	11 (6.0)	0	6
Peripheral vascular disease	170 (92.4)	14 (7.6)	0	6
Age < 55 yr	169 (91.8)	13 (7.1)	2 (1.1)	6
Noncompliant	169 (91.8)	12 (6.5)	3 (1.6)	6
Septic knee arthritis over 1 yr earlier	168 (91.8)	13 (7.1)	2 (1.1)	7
Isolated patellofemoral arthritis	167 (91.8)	8 (4.4)	7 (3.8)	8
No effect				
White race	0	181 (98.4)	3 (1.6)	6
Nonwhite race	0	180 (97.8)	4 (2.2)	6
Male sex	7 (3.8)	171 (92.9)	6 (3.3)	6
Female sex	0	171 (92.9)	13 (7.1)	6
More likely to perform knee replacement				
Pain not responsive to drug therapy	3 (1.6)	8 (4.3)	173 (94.0)	6

*The responses of the 190 surgeons who performed knee replacement surgery during the fiscal years 1984 to 1990 were included. The denominator varied for each characteristic.
†A total of 90% or more of those who responded to the question agreed on how the characteristic affected their decision to perform knee replacement.

ability of knee replacement surgeons may want to consider our analyses. For the factors on which our respondents agreed surgeons may confidently advise patients. For the remainder of the factors, however, surgeons may choose to advise patients of the uncertainty among orthopedic surgeons.

We believe that "clinical disagreement" among surgeons has three possible explanations, which has implications for the strategies that may be used to reduce disagreement. First, disagreement among orthopedic surgeons may reflect the limitation of available knowledge. For example, the surgical literature provides minimal or no information on how numerous patient factors (e.g., age more than 80 years, residence in a nursing home, retirement, employment, knee replacement demanded by patient, sensation of knee instability by patient, ability to walk less than one block without pain, pain at night, non-weight-bearing knee pain, quadriceps lag, varus or valgus deformity, painful feet, radiologic evidence of severe osteoarthritis, painful limitation in active range of knee motion and associated arthritis of the hip) affect the outcome of knee replacement. In the absence of scientific evidence surgeons are required to advise individual patients based on their training and clinical experience. To reduce disagreement among surgeons for these factors, clinical research is necessary to clarify the effect of these factors on the outcome of knee replacement.

The second explanation is that clinical disagreement among surgeons may reflect controversy within the orthopedic literature. For example, some studies suggest that obesity has a detrimental effect on the outcome of knee replacement,[13,19] whereas other studies suggest no effect.[7,20,21] The effect of limited preoperative knee motion is also controversial. One study indicated relatively

Table 3 continued

Patient characteristic	Effect; no. (and %) of respondents*			
	Less likely to perform knee replacement	No effect	More likely to perform knee replacement	No response
Clinical disagreement‡				
Obesity	132 (71.7)	49 (26.6)	3 (1.6)	6
Local psoriasis	104 (56.5)	80 (43.5)	0	6
Weak quadriceps muscle status	101 (55.5)	78 (42.8)	3 (1.6)	8
Quadriceps lag	96 (53.0)	80 (44.2)	5 (2.8)	9
Severe arthritis of hip	86 (47.5)	67 (37.0)	28 (15.5)	9
Nursing-home resident	81 (44.0)	80 (43.5)	23 (12.5)	6
Varus deformity	7 (3.8)	139 (76.0)	37 (20.2)	7
Valgus deformity	11 (6.0)	133 (72.3)	40 (21.7)	6
Employed	43 (23.5)	131 (71.6)	9 (4.9)	7
Painful feet	52 (28.9)	122 (67.8)	6 (3.3)	10
Limitation of active flexion	15 (8.3)	115 (63.9)	50 (27.8)	10
Retired	2 (1.1)	116 (63.0)	66 (35.9)	6
Patient demands knee replacement	51 (27.7)	114 (62.0)	19 (10.3)	6
Limitation of active extension	25 (13.8)	109 (60.2)	47 (26.0)	9
Sensation of instability by patient	23 (12.6)	103 (56.6)	56 (30.8)	8
Radiographic evidence of moderate to severe knee arthritis	3 (1.6)	26 (14.2)	154 (84.2)	7
Pain at night	7 (3.8)	27 (14.8)	149 (81.4)	7
Persistent non-weight-bearing pain	18 (9.9)	20 (11.0)	144 (79.1)	8
Walking without pain limited to < 1 block	21 (11.5)	21 (11.5)	140 (76.9)	8
Age > 80 yr	47 (25.5)	64 (34.8)	73 (39.7)	6

‡Less than 90% of those who responded to the question agreed on how the characteristic affected their decision to perform knee replacement.

little effect,[22] whereas others suggested that patients with limited preoperative motion had less postoperative motion.[7,23] In the presence of contradictory research findings orthopedists in clinical practice are required either to appraise critically the conflicting information and choose the "best" answer or to rely on their clinical experience. Strategies that may be helpful in reducing clinical disagreement for these factors include a formal critical appraisal of the literature, meta-analysis, decision analysis and the consensus of a group of experienced, expert clinicians. If these strategies are not feasible, however, further empirical research may be necessary to clarify the effect of these factors on the outcome of knee replacement.

Finally, surgeons may disagree because the information has not been adequately disseminated to, or adopted by, practising surgeons despite the fact that the factor's effect on the outcome of knee replacement has been clearly demonstrated in the medical literature. For example, despite the disagreement among surgeons observed in our study, most studies suggest that perioperative therapy with anticoagulants reduces the frequency of pulmonary embolism and deep vein thrombosis after knee replacement.[6] Disagreement may occur because some surgeons may not be aware of the information and, therefore, could not have changed their practice. Alternatively, surgeons may be aware of the research but disagree with the findings. They may feel that the studies were performed in patient populations different from theirs, and, thus, the results may not be applicable to their patients. Surgeons may also feel that the results of the studies are biased, or they may disagree with the interpretation of the results. Finally, surgeons, despite recognizing the available literature and agreeing with its content, may choose to treat patients based on their experience and training. In addition, individual patient preferences for treatment may affect surgeons' decision making. Thus, determination of the sources of variation in opinion may be resolved by bringing together a representative group of orthopedic surgeons to discuss the issues of treatment effectiveness and their indications for knee replacement.

Table 4: Frequency with which surgeons would recommend various management options for three hypothetical patients*

	Frequency; no. (and %) of respondents†			
Management option	Never or rarely	Sometimes	Often or always	No response
Patient 1				
Nonoperative management	50 (24.4)	87 (42.4)	38 (18.5)	30 (14.6)
Arthroscopic débridement	50 (24.4)	73 (35.6)	61 (29.8)	21 (10.2)
Osteotomy	14 (6.8)	43 (21.0)	142 (69.3)	6 (2.9)
Unicompartmental knee replacement	126 (61.5)	42 (20.5)	22 (10.7)	15 (7.3)
Tricompartmental knee replacement	162 (79.0)	21 (10.2)	6 (2.9)	16 (7.8)
Patient 2				
Nonoperative management	86 (42.0)	64 (31.2)	32 (15.6)	23 (11.2)
Arthroscopic débridement	128 (62.4)	39 (19.0)	17 (8.3)	21 (10.2)
Osteotomy	174 (84.9)	4 (2.0)	1 (0.5)	26 (12.7)
Unicompartmental knee replacement	178 (86.8)	0	0	27 (13.2)
Tricompartmental knee replacement	14 (6.8)	24 (11.7)	161 (78.5)	6 (2.9)
Patient 3				
Nonoperative management	36 (17.6)	72 (35.1)	78 (38.0)	19 (9.3)
Arthroscopic débridement	35 (17.1)	56 (27.3)	106 (51.7)	8 (3.9)
Osteotomy	120 (58.5)	46 (22.4)	17 (8.3)	22 (10.7)
Unicompartmental knee replacement	161 (78.5)	15 (7.3)	4 (2.0)	25 (12.2)
Tricompartmental knee replacement	76 (37.1)	64 (31.2)	48 (23.4)	17 (8.3)

*Patient 1: 55-year-old businessman with a varus knee and moderate medial compartmental osteoarthritis. Patient 2: 70-year-old woman with a varus knee and severe tricompartmental osteoarthritis. Patient 3: 65-year-old retired man with a varus knee and moderate tricompartmental osteoarthritis. See Appendix 1 for the complete case descriptions.
†The responses of the 205 surgeons who treated patients with osteoarthritis of the knee were included.

The primary indication for knee replacement is pain and functional disability.[6] Our study shows that surgeons consistently identify this as an important indication in their patients. Other studies have suggested that up to 30% of surgical procedures, such as carotid endarterectomy, are being inappropriately performed.[10] Our results suggest that in Ontario most knee replacement procedures are being performed, as indicated, for patients with severe pain and disability. The appropriateness of knee replacement, however, would have to be confirmed by interviewing patients rather than relying solely on the recall of surgeons and ensuring that the patients have no contraindications to the procedure.

In our study surgeons disagreed on how they would treat the three hypothetical patients. The disagreement among the surgeons almost certainly reflects the uncertainty in the orthopedic literature. Clinical trials comparing different treatments for patients with arthritis of the knee may help reduce this clinical uncertainty.

Surgeons who performed more knee replacement procedures in our study had more favourable impressions of the outcome of the procedure. If the volume of procedures performed is truly related to outcome this may have two explanations. First, surgeons who perceive the outcomes of knee replacement to be more favourable may be more likely to offer knee replacement to their patients. Alternatively, surgeons who perform more procedures may have higher success rates and lower complication rates. The latter explanation, if true, has important policy implications for surgeons performing knee replacement. Further study is needed to determine whether the volume of knee replacement procedures performed is causally related to patient outcome.

Our study has several limitations. First, what surgeons say they do in a survey and what they actually do in their clinical practice may be different. Second, disagreement among surgeons for many patient characteristics could be attributed to looking at only one patient factor in isolation. Because patients are clinically varied and complex, a single factor may affect the decision to perform knee replacement differently in different patients. For many factors, however, more than 10% of the surgeons indicated that a given factor made them more likely to perform knee replacement, and more than 10% indicated that the same factor made them less likely to perform the procedure. This diametric disagreement suggests that patient complexity cannot explain all the disagreement among surgeons. Moreover, hypothetical case histories were used to describe three patients in more detail in an attempt to capture the complexity of individual patients,[16] and the surgeons still disagreed on the therapeutic approaches for these patients. Third, a different choice of patient factors or a differential weighting scheme might have affected the disagreement among orthopedic surgeons on the indications for knee replacement. The chosen factors, however, were felt by our orthopedic advisory boards to be the most important ones affecting surgeons' decision to perform knee replacement. Furthermore, if disagreement among surgeons was solely due to our choice of factors, we would

Table 5: Median (and interquartile range) for surgeons' expected outcomes for patients after knee replacement

Outcome	Physician group;* expected % of patients with outcome				
	No patients with knee arthritis (n = 29)	Patients with knee arthritis but no knee replacement procedures (n = 15)	Low volume of knee replacement procedures (n = 85)	High volume of knee replacement procedures (n = 105)	*p* value†
Significant reduction in pain 2 yr after surgery	90.0 (80–95)	90.0 (85–95)	90.0 (90–95)	93.0 (90–95)	0.0002
Improvement in ability to walk	80.0 (80–90)	90.0 (85–95)	90.0 (85–95)	91.0 (90–95)	0.0002
Improved quality of life	90.0 (80–90)	90.0 (90–95)	90.0 (90–95)	92.0 (90–95)	0.003
Deep infection in first 30 d	1.5 (1–3.75)	1.0 (1–2)	1.0 (1–1.5)	1.0 (1–1.5)	0.0006
Above-knee deep vein thrombosis in first 30 d	10.0 (5–30)	12.5 (6–20)	10.0 (52–7.5)	10.0 (5–20)	0.85
Pulmonary embolism in first 30 d	2.0 (1.5–7.5)	3.0 (1–5)	2.0 (1–5)	2.0 (1–5)	0.10
Death in first yr	5.0 (1–5)	3.0 (1–5)	2.0 (1–5)	2.5 (1–5)	0.09
Repeat total knee replacement within 1 yr	2.0 (1–2.5)	2.0 (2–4)	2.0 (1.75–3)	1.0 (1–1.5)	0.02
Repeat total knee replacement within 10 yr	20.0 (10–30)	15.0 (10–20)	15.0 (10–25)	10.0 (5–15)	0.001

*Low volume: less than or equal to the median number of procedures performed per year during the study period; high volume: more than the median number per year.
†Correlation of the responses with the number of procedures performed.

not have expected to also find disagreement among surgeons on the usefulness of treatments for osteoarthritis and of cointerventions for patients receiving knee replacement and on the perceived outcome of knee replacement. Fourth, misinterpretation of the survey questions may have caused surgeons to respond differently. However, because the survey was pilot tested with several groups of orthopedic surgeons from various geographic areas to minimize misinterpretation of the questions, this appears to be an unlikely explanation for the surgeons' disagreement. Fifth, the characteristics of the respondents and nonrespondents were slightly different. However, because the surgeons' characteristics minimally affected their response to the survey, we believe this factor would have minimally affected the results. Sixth, some of the differences in the expected outcomes of knee replacement may be explained by differences in the surgeons' patient populations. For example, the surgeons with a high volume of procedures may perform knee replacement in patients who are more likely to have better outcomes. However, for higher-volume surgeons, who would be expected to treat a similar spectrum of patients, patient variation is unlikely to fully account for the variation in expected outcomes. Finally, we surveyed only orthopedic surgeons in Ontario. Thus, the results are not necessarily generalizable to other surgeons in Canada and the United States.

In conclusion, we found that orthopedic surgeons demonstrate consensus for some of the indications for knee replacement. For the remaining areas of controversy interaction among surgeons is necessary to determine the source of disagreement. The areas of greatest disagreement should be the focus of future research, the development of practice guidelines and the implementation of strategies to change surgeons' behaviour.

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Appendix 1: Case descriptions of three typical hypothetical patients with osteoarthritis of the knee

Case 1	Case 2	Case 3
A 55-year-old businessman is referred to your office complaining of a 1-year history of increasing pain in both knees, but especially the right, after walking as little as two to three city blocks, on climbing up and down stairs and occasionally while sitting at his desk or in meetings. He has been able to perform his activities of daily living but has had to cut back on his previously active lifestyle because of his knee problem. He describes no other mechanical symptoms. He has failed all conservative medical therapy including a battery of nonsteroidal anti-inflammatory drugs (NSAIDs) and analgesics. He has had no prior surgery on either knee but would consider surgery if it were felt to be necessary. On physical examination, he is trim, fit and physically a good surgical candidate. A fluid bulge is noted in both knees. Range of motion of both knees is greater than 90°, but there is evidence of a 10° varus deformity of the right knee associated with 5° of collateral ligament instability. X-ray films of the knees show focal loss of cartilage down to bare bone in the medial compartment in the right knee. You perform arthroscopy and confirm the unicompartmental nature of his disease.	A 70-year-old woman is referred to you complaining of a 6-month history of moderate to severe pain in the left knee with all activities, including at rest and at night while in bed. She has had difficulty sleeping because of the pain. She has also been unable to do even light housework. All usual medical management including a variety of NSAIDs, intra-articular corticosteroids, physiotherapy and an attempt at weight reduction have failed. She is known to have hypertension, controlled on medications, and has non-insulin-dependent diabetes managed with insulin and diet. She is willing to undergo surgery if it is indicated. She has had no prior surgery on either knee. On physical examination, her weight is 91 kg, height 162 cm. The range of motion in the left knee is less than 70°, with evidence of a 15° to 20° varus deformity and approximately 10° of collateral ligament instability in the same knee. No effusion is noted. X-ray films show severe tricompartmental disease of the left knee.	A 65-year-old retired man is referred to you complaining of moderate pain for the past 2 months in his left knee. The pain has worsened over the past 6 months such that now he has pain after walking only four holes on the golf course, as well as on climbing stairs. He does not complain of rest pain or of pain at night. He has had no difficulty performing his activities of daily living but has had to curtail his regular golf games because of his knee pain. He has no other mechanical symptoms. NSAID therapy has failed, as has a trial of physiotherapy. He has undergone a tricompartmental knee replacement in the right knee 2 years previously, which was very successful, and is anxious to have the same procedure on the left knee. He is otherwise well with the exception of a history of peptic ulcer disease, for which he takes misoprostol. On physical examination, he weighs 72 kg and is 178 cm in height. Range of motion of the left knee is greater than 90°, with a 5° varus deformity and 5° of collateral ligament instability. On X-ray films of the left knee, there is evidence of some cartilage remaining in all three compartments.